PHYS 416/517 – Computational Physics – Spring 2020

Instructor: Frank Toffoletto (toffo@rice.edu), HBH 362, x3641
Time: Tuesday/Thursday, 1:00 – 2:20 pm
Location: TBA
Website: canvas.rice.edu
Office Hours: Open door or by appointment
Information in this syllabus, apart from the absence policy, may be subject to change.

Overall course objectives and expected learning outcomes

By the end of this course you should be able to:

- Use computational techniques to solve real-world physical problems.
- Have a working familiarity of some basic numerical methods, including an understanding of how to choose and evaluate appropriate methods for a given problem.
- Use effective and clear programming and debugging strategies in your programming.
- Use a new programming language that you were not previously familiar with (PHYS 517).

Introduction

This course is meant to be a hands-on introduction to the various computational techniques that can be used in physics. It is not meant to replace a formal and rigorous course on numerical methods or to be a course that where you learn the latest modern practices in computer science. In this course, we will tackle a variety of interesting, real-world physics problems using computational techniques. Although most traditional physics courses concentrate on examples and problems for which elegant analytic solutions exist, most real world problems require the use of numerical techniques. As with anything, when you attempt to use such techniques, there are tradeoffs. It is often the case that the computer has generated for you a numerical solution for some problem, however unless you have a rigorous proof of convergence, you can never be sure that the answer you have is correct. In many cases a convergence proof is simply not practical, so in attacking some of the kinds of problems we hope to do in this course you should develop a healthy amount of skepticism coupled to a fair bit of intuition on the problem you are doing.

Some of you may have already been exposed to many of the techniques in other courses, this course will not try to reproduce this, but instead endeavors to tie together this knowledge as applied to real world physics problems. However, I will assume only basic knowledge of numerical methods. The goal of this class is not to be as comprehensive or particularly deep as a numerical methods class, but rather to develop working skill set that will allow you to use in your career.

Rather than using the traditional formal lecture format that can be rather unproductive, the course is hands-on: I believe the best way to learn something is to actually do it. You will work though various problems and exercises taken from the book or other locations which will consist mostly of programming along with the occasional calculation.

Grading

70% of the grade comes from in-class assignments. They are graded based on criteria that include the quality of the program and algorithm, comments and documentation and results. An additional **5%** of your grade will be for class participation.

There is also a **major project** that is due somewhere before the beginning of the last month of classes. The project is worth **25%** of the final grade. Before the project is started, each student is required to submit a project proposal that is graded and worth 20% of the final project grade (5% of the final grade). Students then present the final project to the class and have each student run the project program. A peer grading system will be used.

Late Policy: Unless there are mitigating circumstances, assignments will be due at specified dates. Any work handed in late will have the grade reduced by 10% for each part of a day late, up to 50% off.
Honor code: You are welcome to help each other in completing assignments, but all work that you turn in must be your own and will fall under the pledged policy. Any evidence of copying will result in an automatic zero for the assignment for all parties involved and in some cases honor council involvement.

Absence Policy: If you expect to be absent for any period of time, please inform me ahead of time so I can plan accordingly. Since this class is heavily dependent on assignments, please make sure that you do not fall behind. In the event of illness or any other unforeseen circumstances, please contact me ASAP.

Differences between PHYS 416 and PHYS 517

If you are enrolled in PHYS 517, you will be expected to complete a substantial project that will take up much of the semester. You will be required to use a low-level programming language that **you do not know** (such as C, C++, F95, java) for the project, the selection of which is subject to prior approval. Details on the timeline and grading for the project will be forthcoming. (You can use MATLAB/PYTHON for plotting results.)

If you are enrolled in PHYS 416, you will also be expected to complete a project but expect to spend the latter third of the semester working on it using the MATLAB/PYTHON language.

Textbook

The highly recommended textbook will be Alejandro L. Garcia, *Numerical Methods for Physics*, (CreateSpace Independent Publishing Platform; Second edition, Revised edition (June 6, 2015) 978-1514136683LC Call No.: QC20.G37 2000). I**t is available on amazon for $19** (http://www.amazon.com/Numerical-Methods-Physics-Alejandro-Garcia/dp/1514136686/ref=sr_1_1?s=books&ie=UTF8&qid=1452614947&sr=1-1) **and at the Rice campus bookstore for $14.25 (you can also rent for event less)**. The book has a website for downloading programs, etc. The URL for the programs is: http://www.algarcia.org/nummeth/Programs2E.html There is also an errata, located at: http://www.algarcia.org/nummeth/errata_NM2.pdf.
In 2017 a python version of the book was also made available ($17 on amazon), along with python code. https://www.amazon.com/Numerical-Methods-Physics-Python-Alejandro/dp/1548865494/

Programming Languages

One of the advantages of the Garcia book is that it gives examples in 4 programming languages: MATLAB, C++, python and even Fortran (from the website). You are free to choose whatever programming language you are most comfortable with. I would recommend either:

- MATLAB: If you are unsure and relatively new to programming, I would recommend MATLAB for its versatility and ease of use.
- PYTHON: If you have MATLAB/programming experience and want to learn something new, then PYTHON is also an excellent option. PYTHON is available free on the web and we will be using the numpy and matplotlib modules.

All the PCs in the classroom should have MATLAB and PYTHON installed (and the SPYDER IDE), however of you prefer to use your own laptop there is a student version of MATLAB available for free on the IT website and you can download python for free off the internet.

Students with Disabilities

Any student with a documented disability needing academic adjustments or accommodations is requested to speak with me during the first two weeks of class. All discussions will remain confidential. Students with disabilities will need to also contact Disability Support Services in the Ley Student Center.